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1.	Your reference	PDG/20950
2.	Patent application number *(The Patent Office will fill in this part)*	09 OCT 1998 **9822087.4**
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	SNELL & WILCOX LIMITED 6 Old Lodge Place St Margaret's Twickenham Middlesex TW1 1RQ
	Patents ADP number *(if you know it)*	5579784003
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
4.	Title of the invention	IMPROVEMENTS IN DATA COMPRESSION
5.	Name of your agent *(if you have one)*	MATHYS & SQUIRE
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	100 Gray's Inn Road London WC1X 8AL UNITED KINGDOM
	Patents ADP number *(if you know it)*	1081001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Number of earlier application	Date of filing *(day / month / year)*

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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
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Request for substantive examination *(Patents Form 10/77)*	-
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11. I/We request the grant of a patent on the basis of this application.

Signature MATHYS & SQUIRE Date 9 Sep 1998

12. Name and daytime telephone number of person to contact in the United Kingdom

Peter D Garratt - 0171 830 0000

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~~PROVEMENTS IN~~ ~~A COMPRESSION~~

1. SCOPE

The invention which is the subject of this document is the use of a "reference" MPEG-2 bit-stream input to an MPEG-2 encoder, such that the output of the encoder is controlled by this "reference" input. This input is in addition to and in parallel with other inputs to the encoder which are "prior art".

2. INTRODUCTION

The "reference" MPEG-2 bit-stream input can be regarded as the MPEG-2 equivalent of the "genlock" synchronisation input common on equipment handling uncompressed video. The latter input is used to force the equipment's output to conform with the timing of one particular video signal, whereas the "reference" MPEG-2 bit-stream input is used to force the output of the MPEG-2 encoder to conform with timing and/or other aspects of one particular programme within the multiplex carried by a particular MPEG-2 transport stream signal.

This capability is potentially useful in all multi-programme applications of MPEG-2 in the following categories:

- where MPEG-2 encoders and decoders are cascaded,
- where individual MPEG-2 programmes are to be added, substituted or otherwise combined together, and
- where a non-MPEG-2 programme is to be added, substituted or otherwise combined with programmes within an MPEG-2 transport stream.

For example, if one programme is to be substituted for another within a multi-programme MPEG-2 transport stream which has already been encoded (i.e. it is from "upstream" of the switch system) whilst it is "on-air", MPEG-2 decoders "downstream" of the switch system are very likely to produce noticeable artefacts unless the following critical timing-related MPEG-2 parameters are consistent before and after the switch:

- Access Unit (AU) timing,
- Programme Clock References (PCRs),
- Decode Time-Stamps (DTSs),
- Presentation Time-Stamps (PTSs), and
- Video Buffering Verifier delay ("vbv_delay").

An MPEG-2 encoder can make these critical parameters consistent with another MPEG-2 programme from "upstream" if that MPEG-2 encoder has a "reference" MPEG-2 bit-stream input.

As a second example, it may be beneficial to make the Elementary Stream (ES) bit-rates within a programme being encoded dependent on the bit-rates of one or more other programmes from "upstream". Applications which would benefit from this include various forms of statistical multiplexing and the substitution of one programme for another within a multi-programme MPEG-2 transport stream, without the use of a full (scheduling) MPEG-2 remultiplexer and even where the multi-programme MPEG-2 transport stream has a fully-occupied payload capacity. An MPEG-2 encoder can make the ES bit-rates consistent with another MPEG-2 programme if it has a "reference" MPEG-2 bit-stream input and the latter example application is only made possible by this capability.

3. PRIOR ART

The only external "reference" on pre-existing MPEG-2 encoders are external clock signals from which ES bit-rates and/or total programme bit-rate can be derived. This allows bit-rates to be set with high accuracy, which would allow one MPEG-2 encoder to have bit-rates very close to those of another MPEG-2 encoder.

The "reference" MPEG-2 bit-stream input allows bit-rates to be matched exactly with those from "upstream" encoders. It also allows other MPEG-2 parameters to be matched. It is the exactness of the matching and the greater number of aspects which can be matched which makes the "reference" MPEG-2 bit-stream input different from (and of more practical benefit than) prior art.

4. EXAMPLE APPLICATION DESCRIPTION

The application described below is just one of a number of possibilities, as is the particular implementation outlined below.

MPEG-2 encoders are intended to be used as part of larger MPEG-2 systems in a variety of applications. The example MPEG-2 encoder considered here has the "reference" MPEG-2 bit-stream input and the video MOLE™ technology and is called the "MPC".

The video MOLE™ technology carries additional compression-related information in the serial digital video data path from MOLE™-equipped MPEG-2 decoders to MOLE™-equipped MPEG-2 encoders. This can be used to maximise the picture quality not only whilst transcoding from one compressed data rate to another but also whilst mixing and cross-fading video.

Related to these applications is one in which one programme (the "local" programme) is substituted for another (the "original" programme) within a multi-programme MPEG-2 transport stream broadcast. This application is effectively MPEG-2 "local programme opt-out" and is the example application described below.

The "reference" MPEG-2 transport stream input to the MPC is a major part of the example system implementation which enables broadcasters to perform "local programme opt-out" using MPEG-2 equipment in the same way as they formerly did with analogue equipment. Specifically, this technology enables them to switch between the local programme and the original in the MPEG-2 domain and then disconnect or power down the "local" MPEG-2 encoder and associated video and audio equipment, all without producing any noticeable artefacts when the MPEG-2 service is finally decoded at its destinations.

Avoiding such artefacts involves making certain aspects of the "local" MPEG-2 programme bit-stream consistent with corresponding aspects of the "original" one. The term "co-alignment" will be used for the process of making them consistent.

In this application, the "reference" MPEG-2 input to the MPC is a delayed copy of the whole "original" MPEG-2 bit-stream. The MPC extracts key information from this input in real time so that it can co-align the "local" MPEG-2 bit-stream. The system architecture is shown in Figure 1.

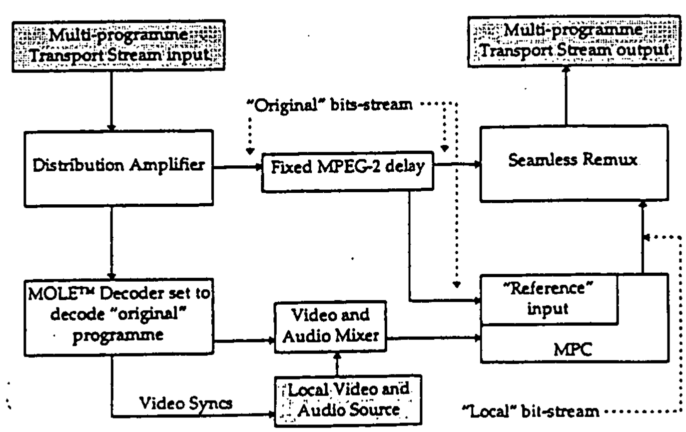

Figure 1: Simplified architecture for local opt-out system

The video MOLE™ technology is also used for this application. It is a major source of information about the "original" programme for co-alignment purposes. The "reference" MPEG-2 transport

s...am input is used to extract aspects of the "original" progra...e, and of the "original" multi-programme bit-stream as a whole, which are less practical to convey via the video MOLE™ data stream. For example, the timing of individual transport packets can be followed by the MPC to simplify the "Seamless Remux". This is "transport packet co-alignment". Transport packets are too frequent to be able to convey their timing in the the video MOLE™ data stream, so the "reference" MPEG-2 transport stream input is used for this instead.

Other co-alignment issues for the "local programme opt-out" application are described below. These also illustrate the practical use of the "reference" MPEG-2 bit-stream input to the MPC in Figure 1.

4.1 Access Unit (AU) co-alignment

Even when using the video MOLE™ technology, DCT rounding makes encoding video AUs to exactly the same number of bits as in the "upstream" encoder impossible to guarantee. Co-aligning the AUs therefore requires an arrangement such as Figure 2. This has control logic within the MPC to align locally-encoded AU headers with corresponding AU headers in the reference transport stream.

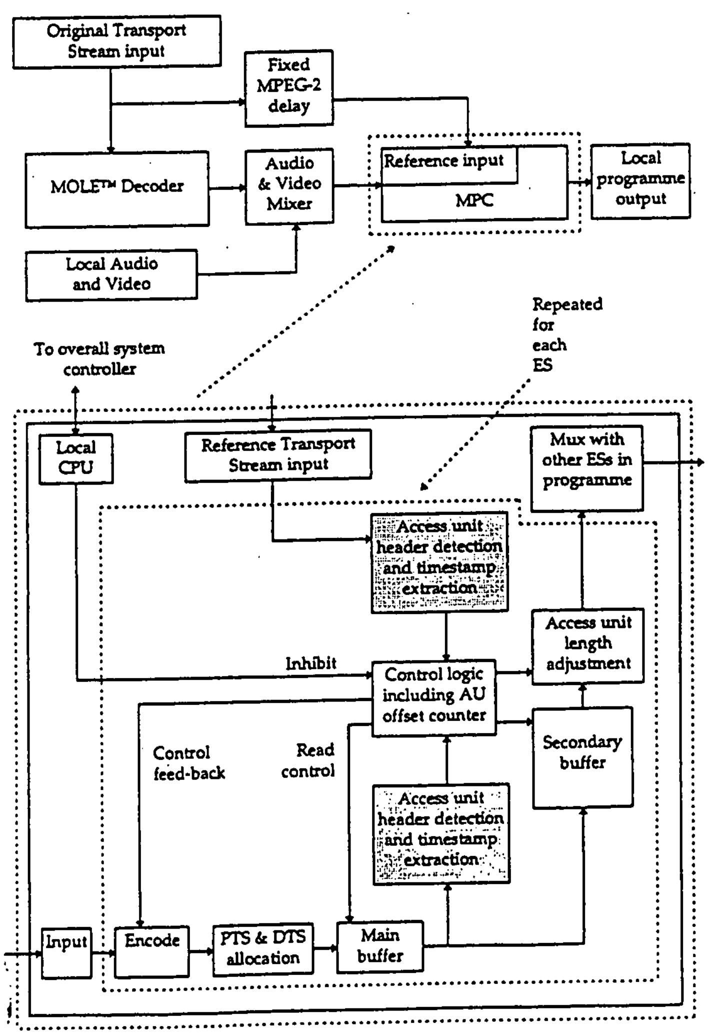

Figure 2: Generalised AU co-alignment architecture

Figure 2 is a generalised outline for a non-specific ES. It shows the extraction of AU headers and timestamps (DTSs and PTSs) from the "reference" input. To allow the "control logic" block to calculate the relative timing of "local" and "reference" AUs, AU headers and timestamps are also extracted from the local video input using a form of the video MOLE™ technology which has been extended to carry timestamps.

The "access unit length adjustment" function shown is only needed where a particular ES has AUs of unpredictable length (so that encoded AUs in the "local" programme are not guaranteed to be the same length as in the "original" one). This length adjustment may be performed, for example, by controlling quantisation and by inserting ES padding.

4.2 Initial set-up of fixed MPEG-2 delay using the timestamps

The AU co-alignment implementation described above offers a way to automatically set the "fine" timing of the "local" data path. This is because after the timestamps have been matched up and a local AU header has then arrived before the corresponding one from the reference stream, reading from the local video buffer stops until an AU header arrives from the reference stream. This has the effect of fine-tuning the "local path" delay by changing the local main video ES buffer level.

The AU length adjustment process just described can then be run through once after MPC power-up to fine-tune the video ES buffer level before attempting any seamless switching.

In addition to the "fine-tuning" just described, the AU co-alignment architecture described above offers a way to set the "coarse" MPEG-2 delay timing during system installation. This is done in a special set-up mode ("delay coarse adjust" mode) in which all co-alignment is inhibited. Timestamps are extracted at the shaded blocks in Figure 2 and sent via the "local CPU" to the overall system controller. This can then subtract the timestamps and set the "MPEG-2 delay" accordingly. This time difference extracted from the timestamps sets the MPEG-2 delay tap which feeds the MPC. The MPEG-2 delay tap which feeds the Seamless Remux can then be set to the same value plus a fixed offset for the remaining path delay difference between the two Seamless Remux inputs in Figure 2.

The ability to automate system data path delay set-up in this way shows the benefit of using the video MOLE™ and the "reference" MPEG-2 input together at the MPEG-2 encoder.

4.3 ES content co-alignment

When a switch between bypass and local paths is about to take place, the encoded data within every ES representing the same uncompressed content must be in the same AU in the "local" encoded programme as it is in the "original" one.

For video, co-aligning content requires the arrangement already shown in Figure 2. This shows control logic within the MPC time-aligning locally-encoded AUs with corresponding AUs in the "reference" transport stream. This gives complete content co-alignment for the video by using its inherent picture boundaries.

Similar methods may be used to co-align audio and data services.

4.4 Timestamp co-alignment

When a switch between bypass and local paths is about to take place, the decoder buffer levels (in decoders downstream of the whole local opt-out system) must be the same for each ES between the "local" programme and the "original" one. This constrains the PTSs and DTSs within each local ES.

To meet this constraint, the MPC needs an internal "local" PCR which is consistent with the values passed through the video MOLE™ when they are present, and which continues to run, locked to the rate of the "reference" bit-stream PCR, when values passed through the video MOLE™ are absent (i.e. whilst the system is "opted out" to the local programme). This "local" PCR can then be used for to generate both audio and video timestamps. One possible architecture is shown in Figure 3.

subtract PTSs as well (the difference between PTSs should be the same as between DTSs; the choice of DTSs over PTSs here is arbitrary).

In order for the proposed system architecture to work, it must be possible to subtract video timestamps for any picture, even though PTSs and DTSs may arrive at different times in the "local" and "original" programmes. The MPC always produces timestamps for every picture (within the header of the PES packet which it always produces for every picture). Just in case the "upstream" encoder does not, Figure 3 interpolates timestamps for every picture from those supplied to the MPC by the MOLE™ Decoder.

4.5 PCR and "vbv_delay" co-alignment

PCR and "vbv_delay" values need to be co-aligned to prevent timing "hiccups" in downstream decoders when the local opt-out system performs a seamless switch.

In standalone operation the MPC produces valid "vbv_delay" values (which are only ever present within the video ES), and the timestamp co-alignment implementation described above co-aligns the PCR values used internally to the MPC. However, the "vbv_delay" and PCR values output by the MPC would still be incorrect for the following two reasons.

- The AU co-alignment scheme shown in Figure 2 introduces an ES delay in the "secondary buffer". This "padding delay" acts is in addition to the main ES buffer delay which would apply in stand-alone operation. The "padding delay" is needed as "local path" delay fine-tuning but it invalidates the "vbv_delay" values which pass through it. This is because the main video ES buffer, including the "padding delay", is a single buffer whose occupancy is used to calculate the local "vbv_delay" values.
- Figure 2 also adds a variable delay by holding up local AU headers during AU length adjustment, which invalidates the PCR values which pass through it by adding large amounts of jitter.

To correct for these effects, "vbv_delay" and PCR values can be re-calculated from scratch just before the output of the MPC. Figure 4 shows one possible implementation of this "re-stamping".

The "variable offset" to the PCR bus shown in Figure 4 is the same "offset" as is shown in Figure 3. The "timestamp extraction" block shown in Figure 4 is the same one used to identify each "local" video AU for AU co-alignment (the lower of the two shaded blocks in Figure 2). The timestamp extracted from the video ES is the DTS value (or the PTS if there is no DTS) because "vbv_delay" is a time interval before decoding rather than before presentation.

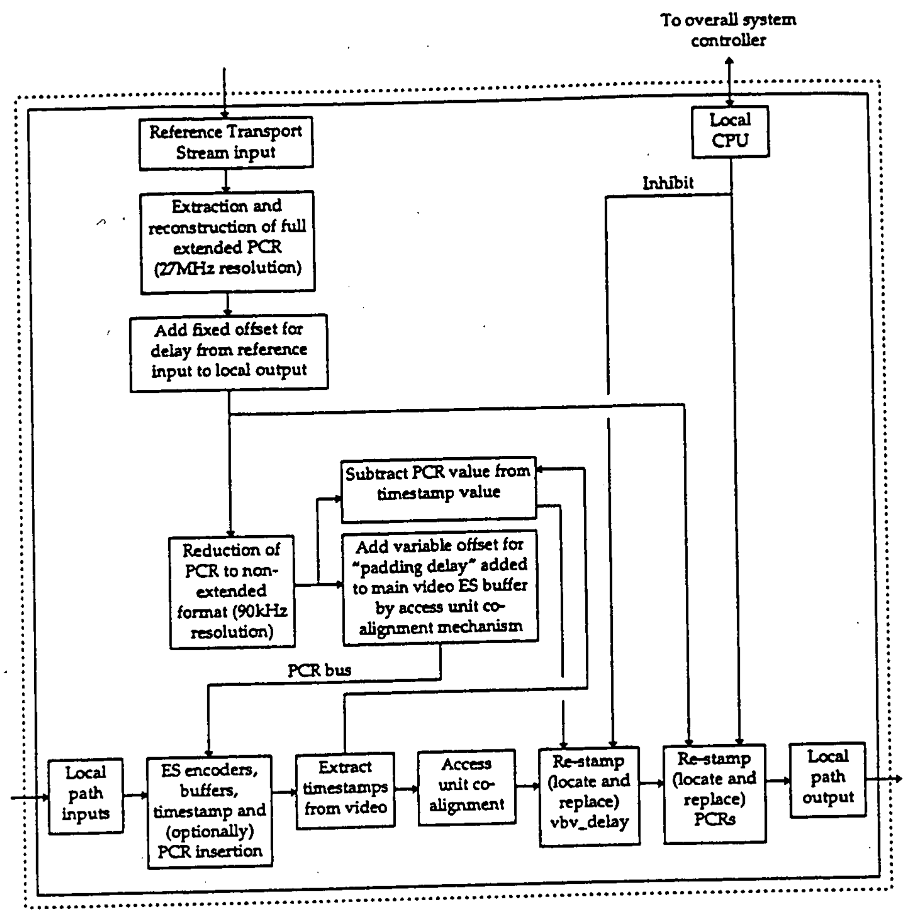

Figure 4: Re-stamping within the MPC

4.6 Conclusion

Each of the preceding co-alignment mechanisms is dependent on extracting timing-related information from the "reference" input to the MPC within the local opt-out system. Co-alignment of each parameter is vital to guarantee that the "local opt-out" can be seamlessly switched in and out, i.e. without artefacts at "downstream" decoders.

In addition, the "reference" input has been shown to allow automatic system data path delay equalisation when used in conjunction with the video MOLE™ technology.

The forgoing clearly demonstrates the dependence of this application on the "reference" input to the MPEG-2 encoder the practical benefits of this input within real-world MPEG-2 systems.

5. PATENT CLAIMS

- The first incorporation of an MPEG-2 transport stream input in an MPEG-2 encoder.
- The first use of the this "reference" input in "local programme opt-out" MPEG-2 applications.

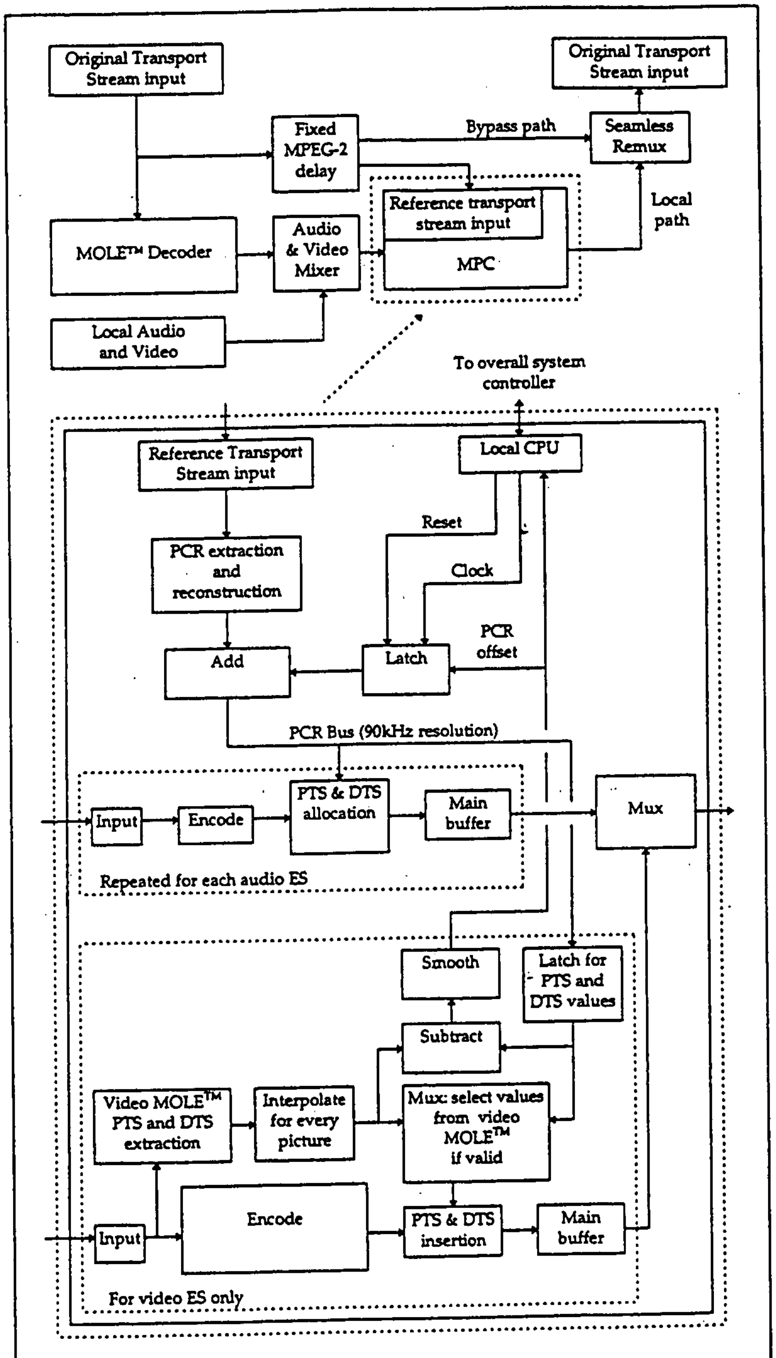

Figure 3: Timestamp co-alignment architecture

Although the ES encoding chain is separate for each ES, the local PCR offset is set using the video ES only. This is because only one ES needs to be used to correct the PCR as all ESs must share the same common resulting PCR. Comparing timestamps within all ESs would also complicate the logic. Video is chosen as the ES on which to perform timestamp comparison because it has the best-defined timing (using the Video MOLE™).

The timestamps values for each picture may be a PTS, a PTS and DTS, or neither. If both are present then only DTSs are subtracted (in the "subtract" block in Figure 3) because there is no need to